The Influence of Ecto-Parasites on the behavior of the Indian Wild Ass (*Equus hemionus khur*), in the Wild Ass Sanctuary, Kutch, Gujarat.

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Declaration

I declare that the thesis entitled "The influence of ecto-parasites on the behavior of the Indian Wild Ass (*Equus hemionus khur*) in Wild Ass Sanctuary, Kutch, Gujarat" comprises research work done by me under the guidance of Dr. Siva Sundaresan. The work is original and has not been done earlier by anyone else. Part of this work, which is related to or similar to work done by other researchers, has been cited in this thesis at appropriate places. The results presented in this thesis have not been submitted previously to this or any other university for an M.Sc. or any other degree.

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Certificate

I declare that the thesis entitled "The influence of ecto-parasites on the behavior of the Indian Wild Ass (*Equus hemionus khur*) in Wild Ass Sanctuary, Kutch, Gujarat" comprises research work carried out by Rohini Rangarajan at the Centre for Wildlife Studies under my guidance, during the period 2007-2008, for the Degree of Master of Science in Wildlife Biology & Conservation of the Manipal University. The results presented in this thesis have not been submitted previously to this or any other university for an M.Sc. or any other degree.

Dr. Siva Sundaresan

SUMMARY

Most behavioral studies have focused on how resources and predators drive habitat choice in animals. There has, however, been little research on the role played by parasites in shaping such decisions. In this study, I examine how ecto-parasitic flies influence the behavior of an endangered equid, the Indian Wild Ass (*Equus hemionus khur*).

Historic records suggest that disease has played an important role in shaping population dynamics of the Indian Wild Ass, or Khur. We therefore expect Khur to behave in ways that would reduce their susceptibility to such attacks.

I find that the Khur use open habitats in the afternoon, places and times where flies are least abundant. When in closed habitats with high fly abundance, the Khur show an increase in parasite avoidance behaviors.

This information provides an insight into the mechanisms that drive habitat choice. It tells us why the Khur need different habitats. With an increase in encroachment in the Sanctuary, there are many human induced changes in the landscape. My study can help monitor the impact of such modifications on Khur behavior. This is a useful management tool for wildlife managers looking to protect this population.

Acknowledgements

Any research project would be difficult to carry out without the concerted efforts of a group of people. Applying this statement to my study would be, to say the very least, a complete understatement. What I write here is merely an attempt at deciphering such an immense data set. There are not enough words to express my thanks towards my guide, Dr. Siva Sundaresan. From conception to culmination, this project is as much his as it is mine. I am truly grateful to him for encouraging and guiding a first-timer like me.

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were truly inspiring.

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Chapter 1

1.1 INTRODUCTION

A member of the Equidae family, the Asiatic wild ass (*Equus hemionus*) once enjoyed a widespread distribution, that extended as far as west Germany. Many references made in the manuscript 'Secret History of Mongolia', and by Marco Polo in the 13th century, talk of the presence of numerous herds in Persia, the Middle East, Arabia, Turkestan, and the Gobi. Today, however, the largest population of the species exists in the southern part of Mongolia, with small, scattered populations found else where. Persistent threats of poaching, habitat fragmentation and disease outbreaks are causing a rapid decline in their numbers (Moehlman 2002). It is no wonder then, that these animals are considered a highly endangered and fast disappearing species.

The Asiatic Wild Ass can be divided into two distinct species - *Equus hemionus* , and *Equus kiang*. There are six recognized subspecies of *Equus hemionus,* of which one, the Syrian Wild Ass (*Equus hemionus hemippus*) became extinct in 1927. The others are the North Mongolian Dziggetai (*E. h. hemionus*), the Gobi Dziggetai (*E. h. luteus*), the onager (*E. h. onager)* from Iran, the Turkmenistan and Kazakhstan kulan *(E. h. kulan),* and the Indian Khur (*E. h. khur*). (IUCN 2007)

The Indian Wild Ass (*Equus hemionus khur*), or Khur, is an endangered equid, listed as a Schedule I species of the Indian Wildlife Protection Act, 1972. The Khur was formerly widespread in its distribution, ranging from Syria in the west, through most of central Asia, up to the arid regions in North-West India. It is presently found only in the Little Rann of Kutch (LRK) in Gujarat, India. The region was declared as the Wild Ass Sanctuary in 1973 to protect this unique population.

The Khur are mainly distinguished by their pale, chestnut color and the dark chocolate fringe of hair

on their back. They are very swift animals, and can reach and maintain maximum speeds of up to 50 km per hour (Menon 2003). They have a gestation period of 11 months, and mating and foaling usually occur in the monsoon season, from July to September. While the females live in unstable family groups of varied sizes and composition, adult males are solitary and defend a territory (Shah 1993). There have been two previous studies focusing on the Indian Wild Ass – one provided baseline ecological information on the subspecies (Shah 1993), while the other compared the association patterns of the Khur and Grevy's Zebra (*Equus grevyi*) (Sundaresan 2007). A third study highlighted the land use pattern by people living in the fringe areas of the Sanctuary, and their impact on the Sanctuary, as well as the Khur (Sinha 1994).

Khur populations are mainly concentrated along the fringe areas of the Sanctuary. The landscape of this region is a mosaic of desert mudflats, invasive *Prosopis* shrub land and open grasslands. Studies have shown that most animals choose between different habitats based on three main factors, namely, resources, predators, and parasites (Crook 1964, Jarman 1974, Hagemoen 2002, Moore 2002) Given that the Khur have few predators, we do not know on what basis they choose among these habitats and why. My study was aimed at understanding the mechanisms that drive these choices.

Historic records suggest that disease has played an important role in shaping population dynamics of the Khur (Shah 1993). There have been three recorded disease outbreaks that have caused significant reductions in population numbers – the arthropod-borne disease *surra* in 1958 and 1960, caused by *Trypanosoma evansi*, and the South African Horse Sickness, in 1961. An aerial survey in 1969 estimated the population figures to be as low as 362 individuals. A population estimation study conducted in 2004 recorded a population of 3863 individuals, which shows an increase in Khur numbers. It is therefore possible that the Khur exhibit certain behaviors that would reduce their susceptibility to such parasite attacks.

Knowledge of the preferred habitats of the Khur would help us formulate better conservation strategies for the management of this population. With an increase in encroachment in the Sanctuary, there have been many human induced changes to landscape. Large numbers of salt mines have come up in the saline mudflats of the LRK, reducing the amount of habitat available for the Khur. A number of roads have been constructed for the movement of people and machines. This has increased the disturbance level within the Sanctuary. This study could help monitor the impact of such modifications on Khur behavior.

1.2 STUDY AREA

The Wild Ass Sanctuary (22° 55' N to 24° 35' N; 70° 30' E to 71° 45' E) spans the Little Rann of Kutch region and covers an area of 4954 km^2. It is a desert ecosystem, which can be classified as Rann saline thorn scrub, *Salvadora* scrub and Tropical *Euphorbia* scrub (degradation stage) (Champion and Seth 1968). The predominant shrub is *Prosopis juliflora*, introduced in 1899. There has been an increase in the spread of this species since 1954, when the Forest Department took up the planting of *P. juliflora* in the waste lands around the Little Rann (Joshi 1959). It is now the most important economic species of the region, and is harvested to make charcoal.

The Tropic of Cancer passes through the Little Rann, leading to a semi – arid climate, with large seasonal temperature variations. The average maximum temperature in May is around 44ºC, while the minimum temperature in January can fall as low as 5ºC. The region has an average precipitation rate of less than 300mm, and it has the highest annual evaporation rate in the country. Rainfall occurs mostly during the monsoon months of June-August, while the rest of the year is dry. This turns the Rann into a saline mudflat, almost completely barren, except for certain islands, or bets, that have shrub and grass cover.

It is during this time, however, that maximum human activity takes place within the Sanctuary. The

barren landscape of the Rann is seen to be dotted with scores of salt pans, intent on converting the underground saline water of this region, into edible, common salt. India is the third largest producer of salt in the world, and Gujarat provides for around 72 percent of this demand. There are close to 1,500 salt pans in the Little Rann of Kutch region. While being a highly profitable industry, it has led to a large amount of disturbance within the Sanctuary, not only in terms of the number of workers manning the salt pans, but also as an increase in the number of vehicles plying through the Sanctuary, to carry this salt to the towns.

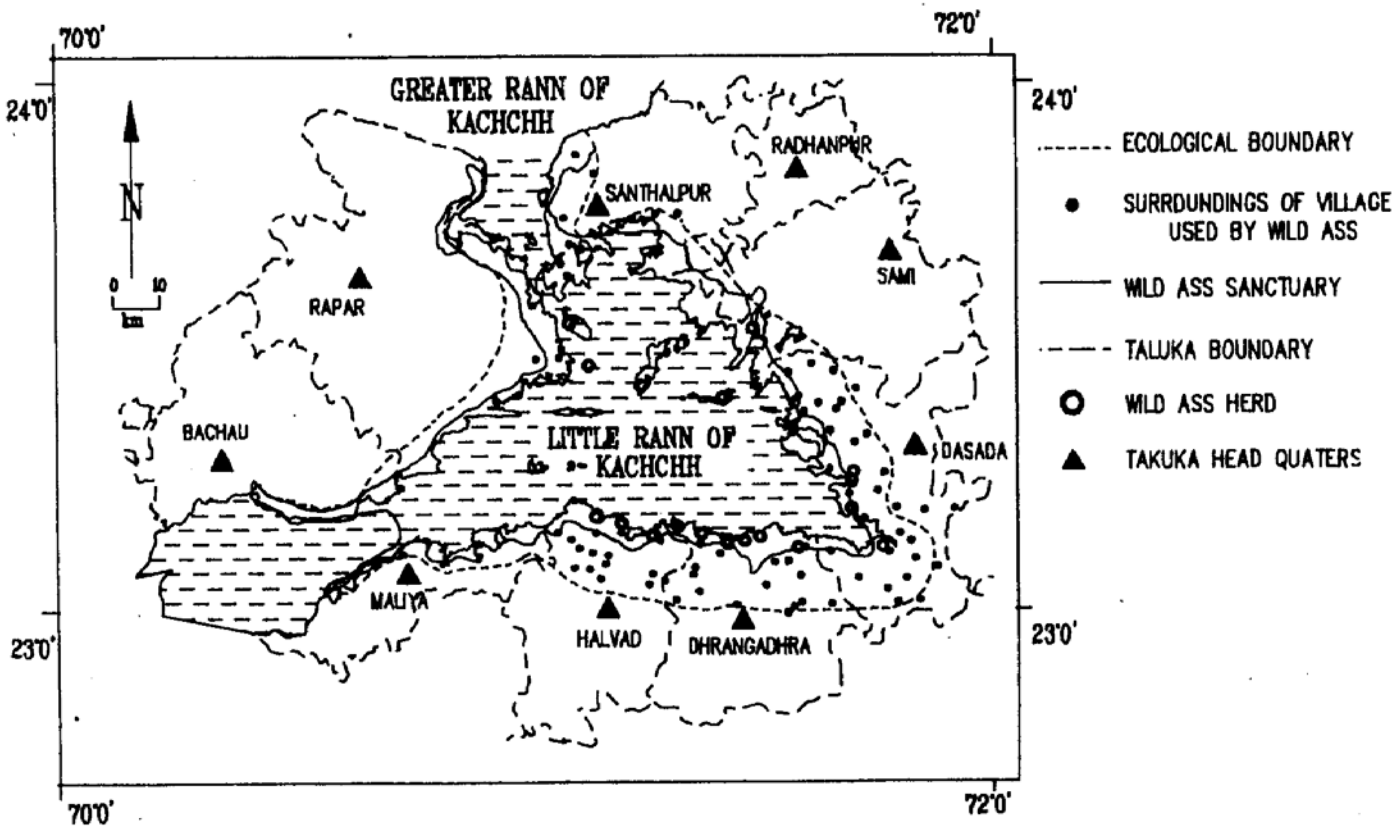
However, in spite of these harsh conditions, a diverse range of animals can be seen here. Apart from the Wild Ass, this region is also home to many other endangered faunal species, including the Houbara Bustard (*Chlamydotis undulata*), black buck (*Antilope cervicapra*) and the Kutch prawns (*Metapenaeus kutchensis*).

1.3 METHODS

The data for this study was collected from the Wild Ass Sanctuary, in Gujarat, India. The field work was done over a period of three months, from January, 2008 to March, 2008. An intensive study area was identified close to the town of Dhrangadhra, in the southern fringe area of the Sanctuary.

The data collected can be broadly divided into three segments. I estimated the diurnal variation in the activity patterns of herds of Khur. Randomly selected herds were followed, and focal animal continuous sampling was carried out to obtain data on their behavior. I also estimated habitat use by the Khur, wherein I drove along a fixed route and noted the number of animals found in different habitats, at different times of the day. Fly abundance was estimated by setting up fly traps in the various habitats.

The results of this study are presented in the form of a manuscript, formatted for submission to the *Journal of Animal Ecology.*



Map showing the Wild Ass Sanctuary, Gujarat, India.

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The Influence of Parasites on Habitat Choice by the Indian Wild Ass *(Equus hemionus khur*).

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2.1 SUMMARY

1. Most behavioral studies have focused on how resources and predators drive habitat choice in animals. There has, however, been little research on the role played by parasites in shaping such decisions. In this study, I examine how ecto-parasitic flies influence the behavior of an endangered equid, the Indian Wild Ass (*Equus hemionus khur*).
2. Historic records suggest that disease has played an important role in shaping population dynamics of the Indian Wild Ass, or Khur. We therefore expect Khur to behave in ways that would reduce their susceptibility to such attacks.
3. I find that the Khur use open habitats in the afternoon, places and times where flies are least abundant. When in closed habitats with high fly abundance, the Khur show an increase in parasite avoidance behaviors.
4. This information provides an insight into the mechanisms that drive habitat choice. It tells us why the Khur need different habitats. With an increase in encroachment in the Sanctuary, there are many human induced changes in the landscape. My study can help monitor the impact of such modifications on Khur behavior. This is a useful management tool for

wildlife managers looking to protect this population.

2.2 INTRODUCTION

Animals choose certain locations to satisfy resource needs, escape from predators or avoid parasites. One of the central challenges in behavioral ecology and conservation is to understand the mechanisms underlying this choice of location. Many studies have examined how predators and resources shape the decisions made by individuals (Crook 1964, Jarman 1974, Hagemoen 2002). There has however, been little research on the role played by ecto-parasites in shaping animal spatial distributions. Studies have shown that animals prefer habitats with low fly abundance. (de Garine- Wichatitsky 1999). For instance, when the abundance of tabanid flies increases, Hippopotamuses tend to avoid foraging on land, and remain almost entirely submerged in water (Moore 2002). Another example is avian malaria in Hawaii, introduced in the early 1900s. The vector for this disease is nocturnal, and restricted to lower elevation regions. Some native Hawaiian birds avoid exposure to this vector by roosting at higher elevations, and foraging in malarious areas only during the day (van Riper 1986).

Many studies have been conducted to determine what factors drive the occurrence of parasites in a particular habitat – research has shown that changes in ambient temperature can have a dramatic effect on the developmental time of parasites (Stirewalt 1954, Takaoka 1982, Halvorsen 1982, Novak 1979, Novak 1986). This could limit the geographical distribution of many parasites to certain habitats (Carruthers 1992). Thus animals can reduce parasite attacks by preferentially choosing habitats with varying temperatures.

When in habitats with high ecto-parasite abundance, animals have been observed to exhibit many avoidance behaviors, such as tail swishing, ear twitching, foot stamping and head tossing (Edman

1987, Hart 1994a, Hart 1994b). Such behaviors increase with ecto-parasite densities, and can cause significant injury to the parasites, thereby reducing the intensity of attacks.

The Wild Ass population in India is the only surviving population of the *hemionus* sub-species in the world. There have already been three recorded disease outbreaks that have caused significant reductions in population numbers. In 1958 and 1960, the population was attacked by the arthropod-borne disease *surra* in caused by *Trypanosoma evansi*, and in 1961 by the South African Horse Sickness An aerial survey in 1969 estimated the population figures to be as low as 362 individuals (Shah 1993). A population estimation study conducted in 2004 (Gujarat Forest Department 2004) recorded a population of 3863 individuals, which shows an increase in Khur numbers. Thus, we can expect that Khur exhibit behaviors that would reduce their exposure to parasites

Having few predators and living in an open habitat makes it easy for Khur individuals to move between herds. Thus parasites may be easily transmitted among individuals in the population. Currently, there is increasing human encroachment on the park boundaries. Along with human numbers, livestock populations have also increased. Thus there is a greater probability of transmission and occurrence of parasite infections between domestic livestock and wild ungulates.

In this paper I examine how ecto-parasitic flies influence habitat choice by the Khur. This is done as a two step process – I first examine the variations in daily activity patterns, to determine habitat choice. Secondly, I estimate the diurnal variations in the abundance of animals in different habitats, and its relation to the fly abundance in the same habitats. This is then used to compare the relative importance of resources as compared to ecto-parasites, as driving forces in determining habitat choice.

I find that the Khur prefer closed habitats at most times of the day, because they are rich in

resources. However, when there is an increase in fly numbers in closed habitats, they move into open habitats. Open habitats, while being resource-poor, also have a low fly abundance. My findings suggest that future conservation action should account for this preference of different habitats. Human activities within the Sanctuary need to be monitored. This is to ensure that the habitats used by the Khur are not reduced, or changed in any manner.

2.3 METHODS

2.3.1 *Study Area*

Field work was conducted from January, 2008 to March, 2008 in the Wild Ass Sanctuary (22° 55' N to 24° 35' N; 70° 30' E to 71° 45' E) in the Little Rann of Kutch, India. An intensive study was carried out close to the town of Dhrangadhra, in the southern fringe of the Sanctuary. This region is a desert ecosystem, with an annual precipitation rate of less than 300mm. (Shah 1993).

2.3.2 *Study Species*

The Indian Wild Ass (*Equus hemionus khur*), or Khur, is an endangered equid, listed as a Schedule I species of the Indian Wildlife Protection Act, 1972. Formerly widespread in its distribution, it is presently found only in the Little Rann of Kutch in Gujarat, India.

2.3.3 *Categories of habitats*

I classified the habitat in my intensive study area into three categories – scrubland, open grasslands, and the Rann. The scrub land, consisting entirely of *Prosopis juliflora* bushes, with interspatial grasses like *Chloris* and *Sporobolus.* The open grasslands are dominated by grass species such as *Cyperus* and *Aeluropus lagopoides,* with almost no *Prosopis* bushes. A third type of habitat is the

Rann, or saline mudflats, which contain no vegetation (Shah 1993).

2.3.4 *Behavioral Sampling*

I measured the diurnal variations in activity patterns of Khur herds in different habitats. I walked within my study area until I found herds of Khur. I randomly chose one herd to follow. I noted behavioral observations of individuals from this chosen herd.

I carried out focal animal sampling of different, identified individuals, to obtain data on behavior (Altmann 1974). In these focals, I recorded various behaviors, which I categorized as:

1) Grazing
2) Browsing
3) Walking
4) Standing
5) Lying
6) Self-grooming
7) Mutual grooming
8) Rolling in mud
9) Tail swishes (per 20 seconds)

Behavioral observation was conducted for a period of 10 minutes, during which all behaviors, including duration of time spent on each, was noted. A 5 minute interval was maintained between consecutive focals, which were usually performed on different individuals in the herd. Five to six different individuals of a herd were followed over a period of 1½ hours. This cycle was repeated five times from 7:30 a.m. To 5:30 p.m., to obtain a diurnal activity pattern for the Khur.

Along with activity patterns, I mapped the route taken by each herd using a GPS, by recording the

herd's GPS location every 20 minutes.

2.3.5 *Habitat classification*:

For each location where the Khur were observed, I measured habitat openness in terms of bush density I used the Bitterlich stick method in which I counted the number of bushes wider than the arc subtended by a 10 centimeter object held one meter away from the eyes (Grosenbaugh 1952). Based on this data, I classified Khur habitat into two categories: closed habitat, consisting of scrub land (Bush density ≥ 3 bushes), and open habitat, which consisted of both grasslands, and the Rann (Bush density ≤ 2 bushes).

2.3.6 *Habitat use*

I also estimated habitat use by the Khur. I drove along a fixed route passing through the different habitats, and noted the number of animals observed in each habitat. The route covered a distance of 55 km, and took 2½ hours to complete. I drove along this route four times a day, at intervals of three hours, from 7:00 am to 6:00 pm.

2.3.7 *Fly abundance*

I sampled for fly abundance in the different habitats, by setting up a total of fifteen fly traps in each of the representative habitats. The data for grasslands and Rann were later combined to get a relative index of fly abundance in closed versus open habitat. A modified version of the "Nzi" fly traps (http://www.nzitrap.com/), which have been used to trap Tsetse and other biting flies in Africa, was used in my study. I monitored the traps twice a week, during which they were checked at intervals of three hours from 7 a.m. to 6 p.m., and the number of flies caught was noted.

2.4 RESULTS

For the purpose of analysis, I divided all of my data into four time periods: (a) 7:00 – 10:00, (b) 10:00 – 13:00, (c) 13:00 – 16:00, and (d) 16:00 – 18:00.

2.4.1 *Diurnal variations in activity patterns*

Khur spend more time grazing in the second time period (10:00 – 13:00), as compared to the first (7:00 – 10:00) and third (13:00 – 16:00), where more time is spent resting (i.e. Standing and lying). In the fourth time period (16:00 – 18:00) however, maximum time is spent grazing.

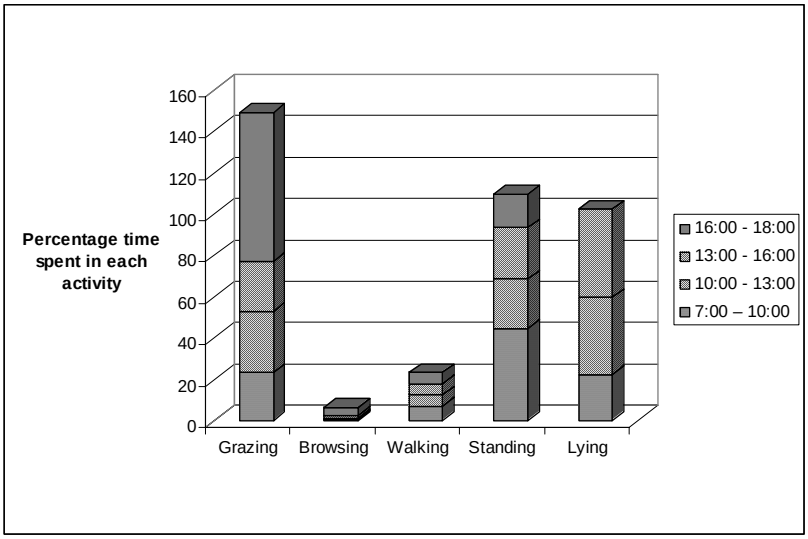

Figure 1: Comparison of time spent in each activity for the four time periods.

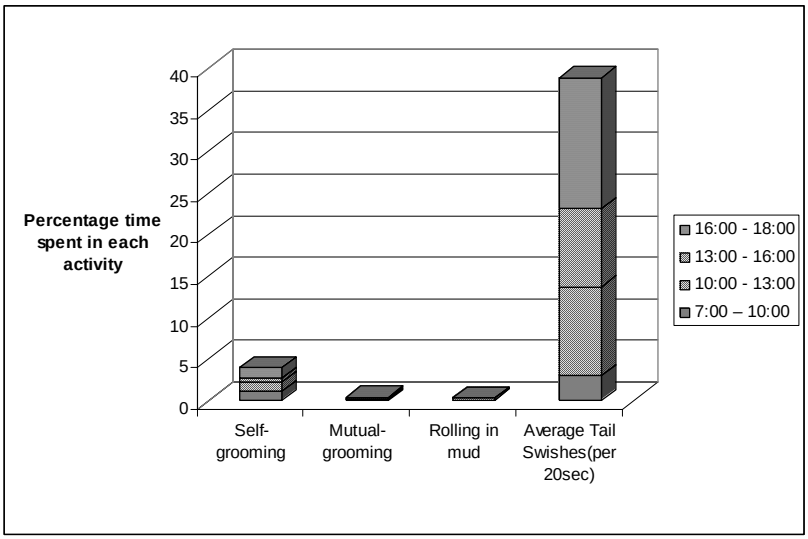

Figure 2: comparison of time spent in avoidance behavior for the four time periods.

2.4.2 *Diurnal variations in habitat use and fly abundance*

There is a decrease in encounter rate of animals in closed habitats, as the average fly numbers increase during the day. Correspondingly, there is an increase in animals found in open habitats, where the fly numbers reduce from morning to afternoon.

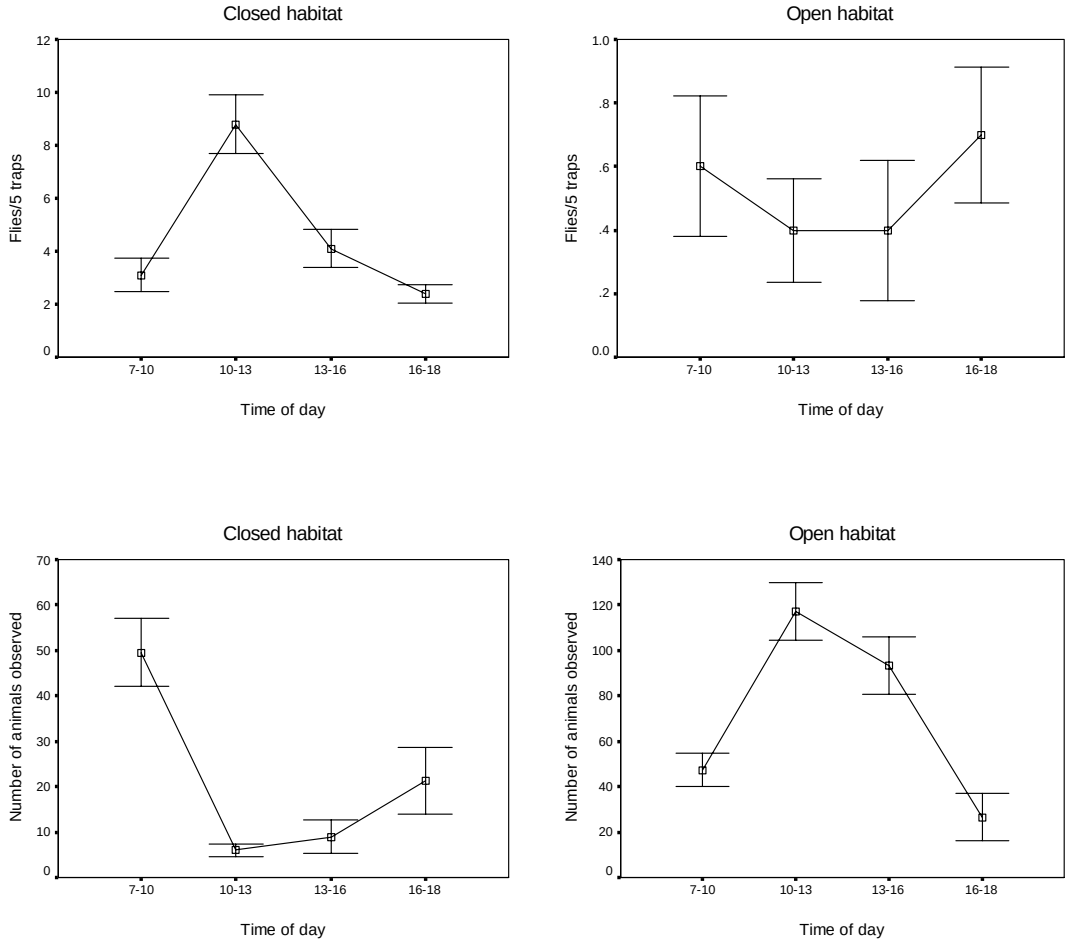

Figure 3: Plot of mean (± 1 SE) fly abundance/5 traps and number of animals observed, for (a) closed and (b) open habitats.

2.5 DISCUSSION

Previous studies have shown that there are three factors which could account for a shift in habitat - resource availability, presence of predators and parasites (Crook 1964, Jarman 1974, Moore 2002). The Khur have very few predators. We would therefore expect habitat choice to be determined by a trade-off between resources and presence of parasites. If Khur movement were driven solely by the need for food and water, they would choose to be in the closed habitats more than in the open habitat. Yet, my data show that Khur use the open habitats, especially in the afternoons. It is, therefore, probable that the Khur move from closed to open habitats, solely to escape from ecto-parasitic attacks.

The beginning part of the first time period (7:00 – 10:00) is spent standing, or lying. From 8:30 onwards, there is a phase of activity and movement. During this phase, the animals begin to graze. It is at this time that fly abundance in scrub land increases drastically. The time spent grooming increases simultaneously, as do the average number of tail swishes. The animals then start moving out from closed to open habitats. This activity phase ends by 12:00, after which maximum time is spent resting. The fly numbers are significantly less in open habitats, as compared to close habitats. Thus there is a decrease in tail swishes as well the time spent grooming. From 14:30 onwards, the animals again begin to move back towards the closed habitats, and a large part of their time is spent grazing. The average number of tail swishes increases then, since the fly numbers in closed habitats, even though they have decreased, is still much higher than that found in open habitats

Though closed habitats have greater resources, they also have a significantly higher abundance of flies as compared to open habitats. When in closed habitats, the animals reduce the level of parasite attacks with an increase in avoidance behavior. However, as the day progresses, there is a rapid increase in fly numbers in these habitats. This drives the Khur into a relatively resource poor, but

parasite-free environment. With a reduction in fly numbers in the evening, the animals return to closed habitats to graze.

My study shows that an effective conservation strategy for the management of this population must account for how the Khur use different habitats. For example, harvesting of *Prosopis juliflora* for charcoal would lead to increased planting of this species, resulting in more bushy areas. As shown in my study, these areas are not preferred by Khur due to parasites. There will thus be fewer habitats available to the Khur because of human impacts. A conservation plan would, therefore, focus on reducing the spread of *Prosopis* in open habitats, or making certain locations where Khur are commonly found, off limits to charcoal harvesting.

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